

Review of the MEPAG Report on Mars Special Regions

Committee to Review the MEPAG Report on Mars Special Regions

European Science Foundation

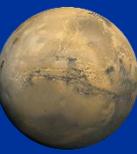
and

National Academies of Sciences, Engineering, and Medicine

David H. Smith

Mars Exploration Program Analysis Group, Silver Spring, Maryland

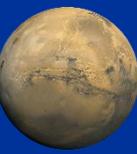
3 March, 2016



The Task

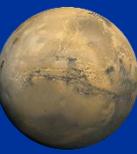
Parallel requests from ESA to ESF and NASA to the Academies in September/October 2014 resulted in the establishment of a joint committee addressing the following statement of task:

An ad hoc committee under the auspices of the National Research Council and the European Science Foundation will review the current planetary protection requirements for Mars Special Regions and their proposed revision as outlined in the 2014 Special Regions report of the Mars Exploration Program Analysis Group (MEPAG). The resulting report from the review shall include recommendations for an update of the planetary protection requirements for Mars Special Regions.



Role of the Academies and ESF

- The planetary protection policies of both NASA and ESA, in accordance with COSPAR policy, entail that requirements imposed on spaceflight missions be determined following receipt of **independent**, multidisciplinary scientific advice. After publication of MEPAG's SR-SAG2 report (reexamining the quantitative definition of Special Regions on Mars) an additional and **independent** view was requested due to the importance of the subject and the potential severe consequences for future Mars missions.
- ESF and the Academies provide a unique interface with their respective scientific communities through their membership organisations and can provide independent advice taking into account all relevant areas of science, including the engineering and social sciences and the humanities.
- As a consequence both NASA and ESA have established arrangements by which the Academies and ESF, respectively to provide strategic advice on planetary protection.



The Joint Committee

PETRA RETTBERG, DLR, Germany, *Chair*

ALEXANDRE ANESIO, University of Bristol, UK

VICTOR BAKER, University of Arizona, USA

JOHN A. BAROSS, University of Washington, USA

SHERRY L. CADY, PNNL, USA

CHRISTINE M. FOREMAN, MSU, USA

ERNST HAUBER, DLR, Germany

GIAN GABRIELE ORI, Universita d'Annunzio, Italy

DAVID PEARCE, Northumbria University, UK

NILTON RENNO, University of Michigan, USA

GARY RUVKUN, Harvard Medical School, USA

BIRGIT SATTLER, University of Innsbruck, Austria

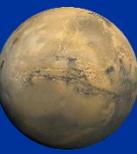
MARK P. SAUNDERS, NASA, retired, USA

DIRK WAGNER, GFZ, Germany

FRANCES WESTALL, CNRS, France

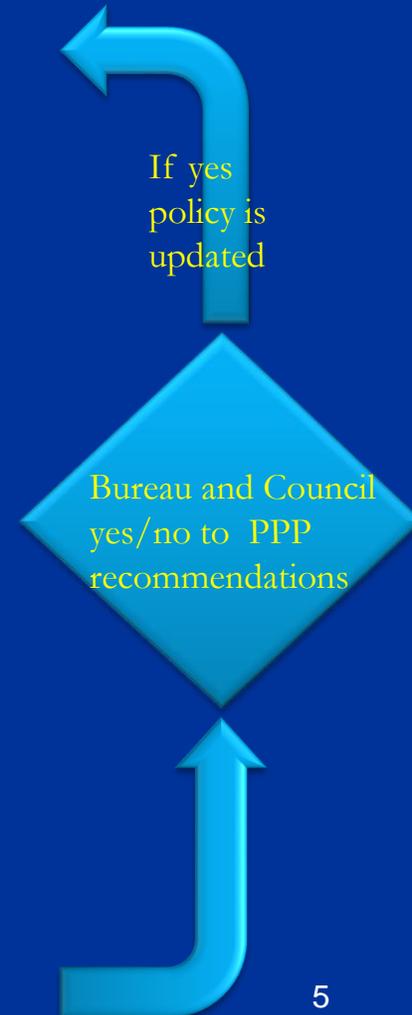
EMMANOUIL DETSIS, European Science Foundation

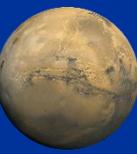
DAVID H. SMITH, the Academies



How are Planetary Protection Policies Set?

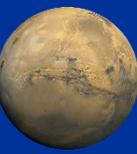
- **COSPAR Planetary Protection Policy**
(COSPAR Bureau and Council-endorsed version)
- **New phenomena reported/new missions proposed/other external considerations**
(Peer reviewed scientific literature/request from private or public entity/recommendations from agency advisory groups)
- **Possible study by a scientific organization and/or a COSPAR-sponsored workshop**
(May be solicited by space agencies and carried out by a National Scientific Institution or International Scientific Unions)
- **COSPAR Panel on Planetary Protection (PPP) meeting**
(Panel business meeting at COSPAR Scientific Assemblies or dedicated COSPAR Panel Colloquium, involving representatives of the scientific community and other relevant stakeholders)





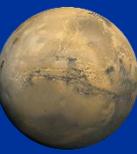
Mars Special Regions

- **2002** COSPAR defines Special Regions as zones “within which terrestrial organisms are likely to propagate, or a region which is interpreted to have a high potential for the existence of extant martian life forms.”
- **2005** NASA adopts definition and commissions NRC to reexamine forward contamination policies for Mars.
- **2005** NRC’s “PREVCOM” report concludes that insufficient data exists to distinguish between special and non-special regions. Recommends that all Mars be considered special until proven otherwise.
- **2006** MEPAG proposes a quantitative definition of Special Regions based on temperature and water activity.
- **2007** COSPAR colloquium discusses conclusions and recommendations of PREVCOM and MEPAG.
- **2010** COSPAR colloquium report conclude that sufficient data exists to distinguish special and non-special regions, adopts a modified form of MEPAG’s quantitative definition and recommends revisit every 2 years.
- **2014** MEPAG reexamines prior work on Special Regions and publishes SR-SAG2 report in Astrobiology.
- **2015** ESF and the Academies publish their review of MEPAG’s SR-SAG2 report.
- **2016** Planetary protection policy revisions based on SR-SAG2 and joint report to be proposed to COSPAR



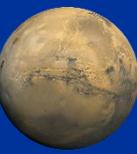
Approach and Timeline

- Organizing Meeting, European Space Science and Technology Center, the Netherlands, October 9, 2014
- Formal appointment of the joint committee, November 19, 2014
- Meeting One, German Research Center for Geosciences, Potsdam, Germany, December 16 – 17, 2014
- Meeting Two, Beckman Center, Irvine, USA, February 12 – 13, 2015
- Final draft of the report sent to eight external reviewers in late-July 2015
- Responses to reviewer comments to the Review Monitor and Coordinator for adjudication, September 1, 2015
- Minor corrections and additions – public release of the report September 21, 2015
- Briefing and discussion at COSPAR Planetary Protection Workshop, Bern, Switzerland, September 22-24, 2015
- Printed report available, December 15, 2015
- Committee authored paper derived from joint report to appear in *Astrobiology*, ?????, 2016
- COSPAR Workshop report to be published in *Advances in Space Research*, ?????, 2016



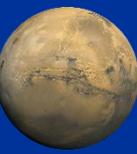
Major Foci of the Joint Report

- The potential for terrestrial organisms to survive and proliferate on Mars
- The relationship between martian geological, hydrological, and mineralogical features and Special Regions
- Issues not falling into the two previous categories, including:
 - Considerations relating to human spaceflight
 - The utility or otherwise of maps to delineate special regions
 - New considerations relating to the definition of Special Regions and
 - Aspects of planetary protection not discussed in the SR-SAG2 report



Overview of the Findings

1. The SR-SAG2 report is a comprehensive review of Special Regions and the factors used to define them.
2. The committee supports 29 of SR-SAG2's 45 specific findings, but does not support one of them.
3. The committee suggests revisions to an additional 13 findings and suggests that two more be combined.
4. The parameters used by MEPAG and COSPAR to define Special Regions are still appropriate.
5. The specific terrains currently identified as special are best regarded as “Uncertain Regions.” The committee recommends that the final determination be made on a case by case basis as part of the landing-site selection process.
6. The identification of Special Regions is problematic for several reasons:
 - Detailed knowledge of the physical and chemical conditions of the surface and sub-surface of Mars at various scales is lacking, particularly the microscale; and
 - Current understanding of the ability of life to propagate is limited.



Definition of Special Regions

A Special Region is defined as a region within which terrestrial organisms are likely to replicate. Any region which is interpreted to have a high potential for the existence of extant martian life forms is also defined as a Special Region.

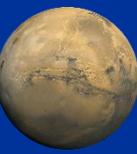
Given current understanding of terrestrial organisms, Special Regions are defined as areas or volumes within which **sufficient water activity AND sufficiently warm temperatures** to permit replication of Earth organisms may exist. The physical parameters delineating applicable water activity and temperature thresholds are :

Lower limit for water activity: 0.5; Upper limit: 1.0

Lower limit for temperature: -25C; No upper limit defined

Timescale within which limits can be identified: 500 years

no change



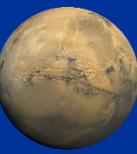
Delineating Special Regions

Observed features for which there is a significant (but still unknown) probability of association with liquid water, and which should be considered as Uncertain Regions and treated as Special Regions until proven otherwise:

- Sources of methane (if located)
- Recurring slope lineae
- Gullies, and bright streaks associated with gullies
- Pasted-on terrains
- Caves, subsurface cavities and subsurface below 5 meters
- Others, to be determined, including dark slope streaks, possible geothermal sites, fresh craters with hydrothermal activity, modern outflow channels, or sites of recent seismic activity

additions

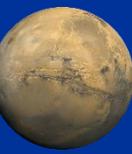
Spacecraft-induced special regions are to be evaluated, consistent with these limits and features, on a case-by-case basis. Organizations proposing to investigate any region that may meet the criteria above, have the responsibility to demonstrate, based on the latest scientific evidence and mission approach, whether or not their proposed landing sites are or are not Special Regions.



The Known Unknowns

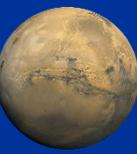
Both SR-SAG2 and the joint committee identified a number of critical issues for which answers are not currently known. These known unknowns include the following:

- Can an organism replicate if it only has access to water vapour and not liquid water?
- Is replication possible if water activity (a_w) and temperature (T_c) exceed critical values asynchronously?
- Have experiments to determine lower temperature limit for replication been conducted on sufficiently long timescales to study extremely slow-growing microorganisms?
- Can a single terrestrial organism propagate on Mars even if a_w and T_c are appropriate?
- Do multispecies colonies have an enhanced ability to proliferate in extreme conditions?
- Do physical and chemical conditions in microenvironments mirror those of macroenvironment?



Outcome of SR-SAG2 and Joint Committee I

- A draft report summarizing the discussions at the Bern Planetary Protection Workshop was assembled and sent to workshop participants (and members of the joint committee) for comment.
- After vigorous and prolonged discussion via email (near-) consensus was achieved.
- The consensus report contains a series of recommendations for changes to COSPAR policy concerning Special Regions.
- Recommendations to be discussed during the PPP sessions and the Bureau and Council meetings in Istanbul this Summer.



Outcome of SR-SAG2 and Joint Committee II

The official response to the joint study from the AA for NASA/SMD was received on 1 March, 2016 and made the following points:

- **“We recognize that organizations proposing to investigate any region of Mars have the responsibility to demonstrate, based on the latest scientific evidence, whether or not they will be operating within Special Regions.”**
- **“Our next landed mission, Mars 2020, is currently performing a detailed evaluation of the potential for Special Regions as part of their landing site selection process for just this reason.”**
- **“Additionally, we will be reviewing our experiences at Gale Crater to better understand ground truth at previous lander locations.”**